इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS/QC 400000 (1988): Fixed Resistors for Use in Electronic Equipment Generic Specification [LITD 5: Semiconductor and Other Electronic Components and Devices]

"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

IS QC 400000 : 1988
IEC QC 400000 : 1982

(Reaffirmed 2002)

Indian Standard

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT

Generic Specification

(First Reprint APRIL 1991)

UDC 621.316.8:621.38.038

© BIS 1988

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

December 1988

Price Rs 120.00

INDIAN STANDARD

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT

Generic Specification

National Foreword

This Indian Standard, which is identical with IEC Pub 115-1/QC 400000 (1982)'Fixed resistors for use in electronic components—Part 1: Generic specification', issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on 9 August 1988 on the recommendation of Resistors Sectional Committee and approval of the Electronics and Telecommunication Division Council.

Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.

Cross References

In this Indian Standard, the following International Standards are referred to. Read in their respective place the following:

International Standard	*Corresponding Indian Standard*
IEC Pub QC 001001 (1981) Basic rules of the IEC quality assessment System for Electronic Components (IECQ)	IS QC 001001 : 1988 Basic rules of the IEC quality assessment System for Electronic Components (IECQ)
IEC Pub QC 001002 (1981) Rules of Procedure of the IEC quality assessment System for Electronic Components (IECQ)	IS QC 001002 (1988) Rules of procedure of the IEC quality assessment System for Electronic Components (IECQ)

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following International Publications and has decided that they are acceptable for use in conjunction with this standard:

IEC Pub 27-1 (1971) Letter symbols to be used in electrical technology —Part 1: General

IEC Pub 50 International Electrotechnical Vocabulary (I.E.V.)

IEC Pub 60-1 (1973) High-voltage test techniques —Part 1: General definitions and test requirements

IEC Pub 60-2 (1973) Part 2: Test procedures

IEC Pub 62 (1974) Marking codes for resistors and capacitors

IEC Pub 63 (1963) Preferred number series for resistors and capacitors

IEC Pub 68-1 (1978) Basic environmental testing procedures—Part 1: General

IEC Pub 68-2 (1974) Basic environmental testing procedures, Test A: Cold

IEC Pub 68-2-2 (1974) Test B: Dry heat

IEC Pub 68-2-3 (1969) Test Ca: Damp heat, steady state

IEC Pub 68-2-6 (1970) Test Fc: Vibration (sinusoidal)

IEC Pub 68-2-13 (1966) Test M: Low air pressure

IEC Pub 68-2-14 (1974) Test N: Change of temperature

IEC Pub 68-2-20 (1974) Test T: Soldering

IEC Pub 68-2-21 (1975) Test U: Robustness of terminations and integral mounting devices

IEC Pub 68-2-27 (1972) Test Ea: Shock

IEC Pub 68-2-29 (1968) Test Eb: Bump

IEC Pub 68-2-30 (1969) Test Db: Damp heat, cyclic (12+12-hour Cycle)

IEC Pub 117 Recommended graphical symbols

IEC Pub 195 (1965) Method of measurement of current noise generated in fixed resistors

IEC Pub 294 (1969) Measurement of the dimensions of a cylindrical component having two axial terminations

IEC Pub 410 (1973) Sampling plans and procedures for inspection by attributes

IEC Pub 440 (1973) Method of measurement of non-linearity in resistors

ISO 3 (1973) Preferred numbers –Series of preferred numbers

ISO 497 (1973) Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers

ISO 1000 (1973) SI Units and recommendations for the use of their multiples and of certain other units

The Text of the Amendment No. 2 to IEC Pub 115-1/QC 400000 has been incorporated.

This standard is intended primarily for use under the IECQ system. A regular Indian Standard for this component could be different, identical or similar to this standard.

Only the English language text in the International Standard has been retained while adopting it in this Indian Standard.

CONTENTS

SECTION ONE - SCOPE

Clause Page

1. Scope ... 4

SECTION TWO - GENERAL

2. General ... 4
2.1 Related documents ... 4
2.2 Units, symbols and terminology ... 6
2.3 Preferred values ... 9
2.4 Marking ... 9

SECTION THREE - QUALITY ASSESSMENT PROCEDURES

3. Quality assessment procedures ... 10
3.1 Qualification Approval/Quality Assessment Systems ... 10
3.2 Primary Stage of Manufacture ... 10
3.3 Structurally Similar Components ... 10
3.4 Qualification Approval Procedures ... 10
3.5 Quality Conformance Inspection ... 11
3.6 Alternative test methods ... 13
3.7 Unchecked parameters ... 13

SECTION FOUR - TEST AND MEASUREMENT PROCEDURES

4. Test and measurement procedures ... 13
4.1 General ... 13
4.2 Standard atmospheric conditions ... 14
4.3 Drying ... 15
4.4. Visual examination and check of dimensions ... 15
4.5 Resistance ... 15
4.6 Insulation resistance (insulated styles only) ... 16
4.7 Voltage proof ... 17
4.8 Variation of resistance with temperature ... 17
4.9 Reactance ... 19
4.10 Non-linear properties ... 20
4.11 Voltage coefficient ... 20
4.12 Noise ... 21
4.13 Overload ... 21
4.14 Temperature rise ... 21
4.15 Robustness of the resistor body ... 22
4.16 Robustness of terminations ... 22
4.17 Solderability ... 23
4.18 Resistance to soldering heat ... 24
4.19 Rapid change of temperature ... 24
4.20 Bump ... 25
4.21 Shock ... 25
4.22 Vibration ... 25
4.23 Climatic sequence ... 26
4.24 Damp heat steady state ... 27
4.25 Endurance ... 28
4.26 Accidental overload test (for low-power non-wirewound resistors only) ... 32
4.27 Single pulse high voltage overload test ... 35
4.28 Periodic pulse high voltage overload test ... 37
4.29 Component solvent resistance ... 40
4.30 Solvent resistance of the marking ... 40

APPENDIX A. — Interpretation of sampling plans and procedures as described in IEC Publication 410 for use within the IEC Quality Assessment System for Electronic Components ...

APPENDIX B. — Rules for the preparation of detail specifications for capacitors and resistors for electronic equipment

APPENDIX C. — Example of a test equipment for the periodic pulse high-voltage overload test ... 43

FIXED RESISTORS FOR USE IN ELECTRONIC EQUIPMENT

Generic specification

SECTION ONE — SCOPE

1. Scope

This standard is applicable to fixed resistors for use in electronic equipment.

It establishes standard terms, inspection procedures and methods of test for use in sectional and detail specifications for qualification approval and for quality assessment systems for electronic components.

SECTION TWO — GENERAL

2. General

2.1 *Related documents*

IEC Publications

Publication 27-1: (1971)	Letter Symbols to be Used in Electrical Technology. Part 1: General.
Publication 50:	International Electrotechnical Vocabulary (I.E.V.)
Publication 60-1: (1973)	High-voltage test techniques. Part 1: General definitions and test requirements.
Publication 60-2: (1973)	Part 2: Test procedures.
Publication 62: (1974)	Marking Codes for Resistors and Capacitors.
Publication 63: (1963)	Preferred Number Series for Resistors and Capacitors.
	Amendment No. 1: (1967) Amendment No. 2: (1977)
Publication 68:	Basic Environmental Testing Procedures.
Publication 68-1: (1978)	Part 1: General.
Publication 68-2-1: (1974)	Tests A: Cold.
Publication 68-2-1A: (1976)	First supplement.
Publication 68-2-2: (1974)	Tests B: Dry Heat.
Publication 68-2-2A: (1976)	First supplement.
Publication 68-2-3: (1969)	Test Ca: Damp Heat, Steady State.

Publication 68-2-6: (1970)	Test Fc: Vibration (Sinusoidal). Amendment No. 1: (1972)
Publication 68-2-13: (1966)	Test M: Low Air Pressure.
Publication 68-2-14 (1974)	Test N: Change of Temperature.
Publication 68-2-20: (1968)	Test T: Soldering.
Publication 68-2-20A: (1970)	First Supplement: Test Tb: Resistance to Soldering Heat, Method 1.
Publication 68-2-21: (1975)	Test U: Robustness of Terminations and Integral Mounting Devices. Amendment No. 1: (1979)
Publication 68-2-27: (1972)	Test Ea: Shock.
Publication 68-2-29: (1968)	Test Eb: Bump.
Publication 68-2-30: (1969)	Test Db: Damp Heat, Cyclic (12 + 12-hour Cycle).
Publication 117:	Recommended Graphical Symbols.
Publication 195 (1965)	Method of Measurement of Current Noise Generated in Fixed Resistors.
Publication 294: (1969)	Measurement of the Dimensions of a Cylindrical Component having Two Axial Terminations.
Publication 410: (1973)	Sampling Plans and Procedures for Inspection by Attributes.
Publication 440: (1973)	Method of Measurement of Non-linearity in Resistors.

Publication QC 001001 (1981): Basic Rules of the IEC Quality Assessment System for Components (IECQ).

Publication QC 001002 (1981): Rules of Procedure of the IEC Quality Assessment System for Electronic Components (IECQ).

ISO publications

ISO Standard 3: (1973)	Preferred Numbers — Series of Preferred Numbers.
ISO Standard 497: (1973)	Guide to the Choice of Series of Preferred Numbers and of Series Containing more Rounded Values of Preferred Numbers.
ISO Standard 1000: (1973)	SI Units and Recommendations for the Use of their Multiples and of Certain Other Units.

Note. — The above references apply to the current editions, except for IEC Publication 68 for which the referenced edition must be used.

2.2 *Units, symbols and terminology*

2.2.1 *General*

Units, graphical symbols, letter symbols and terminology shall, whenever possible be taken from the following publications:

IEC Publication 27
IEC Publication 117
IEC Publication 50
ISO Standard 1000

When further items are required they shall be derived in accordance with the principles of the documents listed above.

2.2.2 *Type*

A group of components having similar design features and the similarity of whose manufacturing techniques enables them to be grouped together either for qualification approval or for quality conformance inspection.

They are generally covered by a single detail specification.

Note. — Components described in several detail specifications may, in some cases, be considered as belonging to the same type and may therefore be grouped together for qualification approval and quality conformance inspection.

2.2.3 *Style*

A sub-division of a type, generally based on dimensional factors.

A style may include several variants, generally of a mechanical order.

2.2.4 *Grade*

A term to indicate additional general characteristics concerning the intended application e.g. long life applications.

The term "grade" may be used only in combination with one or more words (e.g. long life grade) and not by a single letter or number.

Figures to be added after the term "grade" should be arabic numerals.

2.2.5 *Family (of electronic components)*

A group of electronic components which predominantly displays a particular physical attribute and/or fulfils a defined function.

2.2.6 *Sub-family (of electronic components)*

A group of components within a family manufactured by similar technological methods.

2.2.7 *Rated resistance*

The resistance value for which the resistor has been designed, and which is generally indicated upon the resistor.

2.2.8 *Critical resistance*

The resistance value at which the rated voltage is equal to the limiting element voltage (see Sub-clauses 2.2.15 and 2.2.16).

At an ambient temperature of 70 °C, the maximum voltage which may be applied across the terminations of a resistor is either the calculated rated voltage, if the resistance is less than the critical resistance, or the limiting element voltage if the resistance is equal to or greater than the critical resistance. At temperatures other than 70 °C, account shall be taken of the derating curve and the limiting element voltage in the calculation of any voltage to be applied.

2.2.9 *Category temperature range*

The range of ambient temperatures for which the resistor is designed to operate continuously; this is defined by the temperature limits of its appropriate category.

2.2.10 *Upper category temperature*

The maximum ambient temperatures for which a resistor has been designed to operate continuously at that portion of the rated dissipation which is indicated in the category dissipation.

2.2.11 *Lower category temperature*

The minimum ambient temperature at which a resistor has been designed to operate continuously.

2.2.12 *Maximum surface temperature*

The maximum temperature permitted on the surface for any resistor of that type when operated continuously at rated dissipation at an ambient temperature of 70 °C.

2.2.13 *Rated dissipation*

The maximum allowable dissipation at an ambient temperature of 70 °C under the conditions of the endurance test at 70 °C and for which the permitted change in resistance for this endurance test is not exceeded.

2.2.14 *Category dissipation*

A fraction of the rated dissipation exactly defined in the detail specification, applicable at the upper category temperature, taking account of the derating curve prescribed in the detail specification.

Note. — The category dissipation may be zero.

2.2.15 *Rated voltage* (U_N or U_R)

The d.c. or a.c. r.m.s. voltage calculated from the square root of the product of the rated resistance and the rated dissipation.

Note. — At high values of resistance the rated voltage may not be applicable because of the size and the construction of the resistor (see Sub-clause 2.2.16).

2.2.16 *Limiting element voltage*

The maximum d.c. or a.c. r.m.s. voltage that may be continuously applied to the terminations of a resistor (it is generally dependent upon size and manufacturing technology of the resistor).

Where the term "a.c. r.m.s. voltage" is used in this standard, the peak voltage shall not exceed 1.42 times the r.m.s. value.

Note. — This voltage shall only be applied to resistors when the resistance value is equal to or higher than the critical resistance value.

2.2.17 *Isolation voltage (applicable only to insulated resistors)*

The maximum peak voltage which may be applied under continuous operating conditions between the resistor terminations and any conducting mounting surface.

2.2.18 *Insulated resistor*

A resistor which fulfils the voltage proof and insulation resistance test requirements and the damp heat, steady-state test with a polarizing voltage applied when mounted on a metal plate.

2.2.19 *Insulation resistance*

Under consideration.

2.2.20 *Variation of resistance with temperature*

Variation of resistance with temperature can be expressed either as temperature characteristic or as temperature coefficient as defined below:

2.2.20.1 *Temperature characteristic of resistance*

The maximum reversible variation of resistance produced over a given temperature range within the category temperatures. It is normally expressed as a percentage of the resistance related to a reference temperature of 20 °C.

Temperature characteristic of resistance $= \frac{\Delta R}{R}$, where:

ΔR is the change in resistance between the two specified ambient temperatures.

R is the resistance value at the reference temperature.

2.2.20.2 *Temperature coefficient of resistance* (α)

The relative variation of resistance between two given temperatures (mean coefficient), divided by the difference in temperature producing it. It is normally expressed in parts per million per degree Celsius ($10^{-6}/^{\circ}C$).

$$\alpha = \frac{R_2 - R_1}{R_1 \cdot \Delta\theta}$$

where:

$\Delta\theta$ is the algebraic difference, in degrees Celsius, between the specified ambient temperature and the reference temperature (for calculation see Sub-clause 4.8.4).

Note. — It should be noted that use of the term does not imply any degree of linearity for this function, nor should any be assumed.

2.2.21 *Visible damage*

Visible damage which reduces the usability of the resistor for its intended purpose.

2.3 *Preferred values*

2.3.1 *General*

Each sectional specification shall prescribe the preferred values appropriate to the sub-family; for rated resistance see also Sub-clause 2.3.2.

2.3.2 *Preferred values of rated resistance*

The preferred values of rated resistance shall be taken from the series specified in IEC Publication 63.

2.4 *Marking*

2.4.1 *General*

2.4.1.1 The information given in the marking is normally selected from the following list; the relative importance of each item is indicated by its position in the list:

a) rated resistance.
b) tolerance on rated resistance.
c) year and month (or week) of manufacture.
d) number of the detail specification and style reference.
e) manufacturer's name or trade mark.

2.4.1.2 The resistor shall be clearly marked with *a)* and *b)* above and with as many of the remaining items as is practicable. Any duplication of information in the marking on the resistor should be avoided.

2.4.1.3 The package containing the resistor(s) shall be clearly marked with all the information listed above.

2.4.1.4 Any additional marking shall be so applied that no confusion can arise.

2.4.2 *Coding*

When coding is used for resistance value, tolerance or date of manufacture, the method shall be selected from those given in IEC Publication 62.

SECTION THREE — QUALITY ASSESSMENT PROCEDURES

3. **Quality assessment procedures**

3.1 *Qualification Approval/Quality Assessment Systems*

3.1.1 For a full Quality Assessment System the procedures of Sub-clauses 3.4 and 3.5 shall be followed.

3.1.2 For Qualification Approval without Quality Conformance Inspection (type testing only), the procedures and requirements of Sub-clauses 3.4.1 and 3.4.2*b)* may be used as appropriate, but in any case tests and parts of tests shall be applied in the order given in the test schedules.

3.2 *Primary Stage of Manufacture*

For fixed resistor specifications, the primary stage of manufacture is:

- For film types: the deposition of the resistive film on the substrate.
- For carbon composition types: the process which produces the greatest change in polymerization of the binder.
- For wirewound types: the winding of the resistance wire (or ribbon) on the former.
- For metal foil resistors: the fixing of the resistive foil on the substrate.

3.3 *Structurally Similar Components*

Resistors considered as being structurally similar are resistors produced with similar processes and materials, though they may be of different sizes and values. The grouping of structurally similar components for the purpose of qualification approval and quality conformance inspection shall be prescribed in the sectional specification.

3.4 *Qualification Approval Procedures*

3.4.1 The manufacturer shall comply with:

- the general requirements of the rules of procedure governing qualification approval;
- the requirements for the primary stage of manufacture which is defined in Sub-clause 3.2 of this standard.

3.4.2 In addition to the requirements of Sub-clause 3.4.1 procedures *a)* or *b)* below shall apply:

a) The manufacturer shall produce test evidence of conformance to the specification requirements on three inspection lots for lot-by-lot inspection taken in as short a time as possible and one lot for periodic inspection. No major changes in the manufacturing process shall be made in the period during which the inspection lots are taken.

Samples shall be taken from the lots in accordance with IEC Publication 410 (see Appendix A). The sample shall contain the highest and lowest resistance values represented in the lot and a critical value when this value falls between such high and low values. The highest and lowest resistance values so selected shall define the resistance range for which qualification approval is granted.

Normal inspection shall be used, but when the sample size would give acceptance on zero defectives, additional specimens shall be taken to meet the sample size required to give acceptance on one defective.

b) The manufacturer shall produce test evidence to show conformance to the specification requirements on the fixed sample size test schedule given in the sectional specification.

The specimens taken from the sample shall be selected at random from current production or as agreed with the National Supervising Inspectorate.

3.4.3 Qualification Approval obtained as part of a Quality Assessment System shall be maintained by regular demonstration of compliance with the requirements for Quality Conformance (see Sub-clause 3.5). Otherwise this qualification approval must be verified by the rules for the maintenance of Qualification Approval given in the Rules of Procedure for the I E C Quality Assessment System for Electronic Components (IECQ) (I E C Publication QC 001002, Sub-clauses 11.5.2 and 11.5.3).

3.5 *Quality Conformance Inspection*

The blank detail specification(s) associated with a sectional specification shall prescribe the test schedule for Quality Conformance Inspection.

This schedule shall also specify the grouping, sampling and periodicity for the lot-by-lot and periodic inspection.

Inspection Levels and AQL's shall be selected from those given in I E C Publication 410.

If required, more than one schedule may be specified.

3.5.1 *Certified Records of Released Lots*

When certified records of released lots are prescribed in the relevant specification and are requested by a purchaser, the following information shall be given as a minimum:

- attributes information (i.e. number of components tested and numbers of defective components) for tests in the sub-groups covered by periodic inspection without reference to the parameter(s) for which rejection was made.
- variables information for the change in resistance after the 1000 h endurance test.

3.5.1.1 *Attributes information*

When the relevant detail specification requires that attributes information shall be recorded, the following procedures shall be used:

1) When a sub-group comprises a single conditioning test, the total number of rejected resistors shall be recorded together with the test in which the failures occurred but without reference to the parameters for which the rejection was made.
2) When a sub-group comprises a number of conditioning tests, the relevant detail specification shall state whether the results shall be recorded for the individual conditioning tests or for a number of them as a group. For the purposes of this specification, the climatic sequence shall be deemed to form a single conditioning test.

3.5.1.2 *Measurements information*

The relevant detail specification shall state which tests are to be reported in the Certified Record of Released Lots as measurements information. It shall also state whether results may be aggregated, e.g. by rated dissipation, ranges of rated resistance, etc.

As a minimum, the results of all electrical endurance tests shall be presented as measurements information. To assist a standard presentation, measurements information for endurance tests and current noise shall preferably be given in the following manner:

a) For the endurance tests, the intervals for the parametric change, expressed as a percentage, shall be $\Delta R/R$: 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 3.0; 5.0; 10.0; 15.0 and 20.0 and the time intervals shall be 48 h, 500 h and 1000 h. Separate intervals for positive and negative changes shall be recorded.

When the duration of an endurance test exceeds 1000 h, the additional time intervals of 2000 h, 4000 h and 8000 h shall be used.

If the number of results to be presented is 20 or less, the actual values shall be stated but the identity of the measurements need not be retained. See the Rules of Procedure for the IEC Quality Assessment System for Electronic Components (IECQ) (IEC Publication QC 001002, Clause 14) for the general requirements governing the contents of Certified Records of Released Lots.

b) The results of the measurement of current noise of film and carbon composition resistors shall be presented in the following manner:

Noise in μV per volt	Quantity
>6.4	
>3.2 but ≤ 6.4	
>1.6 but ≤ 3.2	
>0.8 but ≤ 1.6	
>0.4 but ≤ 0.8	
>0.2 but ≤ 0.4	
>0.1 but ≤ 0.2	
>0.05 but ≤ 0.1	
≤ 0.05	

Note. — The contents of the Certified Records of Released Lots shall comply with the requirements given in the Rules of Procedure for the IEC Quality Assessment System for Electronic Components (IECQ) (IEC Publication QC 001002, Sub-clause 14.3).

3.5.2 *Delayed delivery*

Fixed resistors held for a period exceeding two years (unless otherwise specified in the sectional specification), following the release of the lot shall, before delivery, be re-examined for solderability and resistance as specified in Group A and B Inspection of the detail specification.

The re-examination procedure adopted by the manufacturer's Chief Inspector shall be approved by the National Supervising Inspectorate.

Once a "lot" has been satisfactorily re-inspected, its quality is re-assured for the specified period.

3.5.3 *Release for delivery before the completion of Group B tests*

When the conditions of I E C Publication 410 for changing to reduced inspection have been satisfied for all Group B tests, the manufacturer is permitted to release components before the completion of such tests.

3.6 *Alternative test methods*

The test and measurement methods given in the relevant specification are not necessarily the only methods which can be used. However, the manufacturer shall satisfy the National Supervising Inspectorate that any alternative methods which he may use will give results equivalent to those obtained by the methods specified. In case of dispute, for referee and reference purposes the specified methods only shall be used.

3.7 *Unchecked parameters*

Only those parameters of a component which have been specified in a detail specification and which were subject to testing can be assumed to be within the specified limits.

It should not be assumed that any parameter not specified will remain unchanged from one component to another. Should, for any reason, it be necessary for (a) further parameter(s) to be controlled, then a new, more extensive, specification should be used.

The additional test method(s) shall be fully described and appropriate limits, AQL's and inspection levels specified.

SECTION FOUR — TEST AND MEASUREMENT PROCEDURES

4. **Test and measurement procedures**

4.1 *General*

The sectional and/or blank detail specification shall contain tables showing the tests to be made, which measurements are to be made before and after each test or sub-group of tests, and the sequence in which they shall be carried out. The stages of each test shall be carried out in the order written. The measuring conditions shall be the same for initial and final measurements.

If national specifications within any Quality Assessment System include methods other than those specified in the above documents, they shall be fully described.

The issue and amendment status of any I E C Publication 68 test in this section is given in Sub-clause 2.1.

4.2 *Standard atmospheric conditions*

4.2.1 *Standard atmospheric conditions for testing*

Unless otherwise specified, all tests and measurements shall be made under standard atmospheric conditions for testing as given in Sub-clause 5.3 of IEC Publication 68-1:

Temperature: 15 °C-35 °C
Relative humidity: 45%-75%
Air pressure: 86 kPa-106 kPa (860 mbar-1 060 mbar)

Before the measurements are made, the resistor shall be stored at the measuring temperature for a time sufficient to allow the entire resistor to reach this temperature. The same period as is prescribed for recovery at the end of a test is normally sufficient for this purpose.

When measurements are made at a temperature other than the specified temperature, the results shall, when necessary, be corrected to the specified temperature. The ambient temperature during the measurements shall be stated in the test report. In the event of a dispute, the measurements shall be repeated using one of the referee temperatures (as given in Sub-clause 4.2.3) and such other conditions as are prescribed in this specification.

When tests are conducted in a sequence, the final measurements of one test may be taken as the initial measurements for the succeeding test.

Note. — During measurements, the resistor shall not be exposed to draughts, direct sun-rays or other influences likely to cause error.

4.2.2 *Recovery conditions*

Unless otherwise specified, recovery shall take place under the standard atmospheric conditions for testing (Sub-clause 4.2.1). If recovery has to be made under closely controlled conditions, the controlled recovery conditions of Sub-clause 5.4.1 of IEC Publication 68-1 shall be used.

4.2.3 *Referee conditions*

For referee purposes, one of the standard atmospheric conditions for referee tests taken from Sub-clause 5.2 of IEC Publication 68-1, as given below, shall be chosen:

Temperature	*Relative humidity*	*Air pressure*
20 ± 1 °C	63%-67%	86 kPa-106 kPa (860 mbar-1 060 mbar)
23 ± 1 °C	48%-52%	86 kPa-106 kPa (860 mbar-1 060 mbar)
25 ± 1 °C	48%-52%	86 kPa-106 kPa (860 mbar-1 060 mbar)
27 ± 1 °C	63%-67%	86 kPa-106 kPa (860 mbar-1 060 mbar)

4.2.4 *Reference conditions*

For reference purposes the standard atmospheric conditions for reference given in Sub-clause 5.1 of IEC Publication 68-1 apply:

Temperature: 20 °C
Air pressure: 101.3 kPa (1 013 mbar)

4.3 *Drying*

When drying is prescribed, the resistor shall be conditioned before measurement is made using Procedure I or Procedure II as prescribed in the detail specification.

Procedure I: for 24 ± 4 h in an oven at a temperature of 55 ± 2 °C and at a relative humidity not exceeding 20%.

Procedure II: for 96 ± 4 h in an oven at 100 ± 5 °C.

The resistor shall then be allowed to cool in a desiccator using a suitable desiccant, such as activated alumina or silica gel, and shall be kept therein from the time of removal from the oven to the beginning of the specified tests.

4.4 *Visual examination and check of dimensions*

4.4.1 *Visual examination*

The condition, workmanship and finish shall be satisfactory as checked by visual examination (see Sub-clause 2.2.21).

Marking shall be legible, as checked by visual examination. It shall conform with the requirements of the detail specification.

4.4.2 *Dimensions (gauging)*

The dimensions indicated in the detail specification as being suitable for gauging shall be checked, and shall comply with the values prescribed in the detail specification.

When applicable, measurements shall be made in accordance with IEC Publication 294.

4.4.3 *Dimensions (detail)*

All dimensions prescribed in the detail specification shall be checked and they shall comply with the values prescribed.

4.5 *Resistance*

4.5.1 Measurements of resistance shall be made by using a direct voltage of a small magnitude for as short a time as practicable, in order that the temperature of the resistance element will not rise appreciably during measurement. In the event of conflicting results attributable to such test voltages, the voltage specified in the following table shall be used for referee purposes.

Rated resistance (R)	Measuring voltage $V^{+0}_{-10\%}$
$R < 10\ \Omega$	0.1 (see note)
$10\ \Omega \leq R < 100\ \Omega$	0.3
$100\ \Omega \leq R < 1\ k\Omega$	1
$1\ k\Omega \leq R < 10\ k\Omega$	3
$10\ k\Omega \leq R < 100\ k\Omega$	10
$100\ k\Omega \leq R < 1\ M\Omega$	25
$1\ M\Omega \leq R$.	50

Note. — When the rated resistance is less than 10 Ω the measuring voltage shall be so chosen that the resistor is dissipating less than 10% of its rated dissipation, but shall not exceed 0.1 V.

The accuracy of the measuring method shall be such that the total error does not exceed 10% of the tolerance. When the measurement forms part of a test sequence, it shall be possible to measure a change of resistance with an error not exceeding 10% of the maximum change permitted for that test sequence.

4.5.2 The resistance value at 20 °C shall correspond with the rated resistance taking into account the tolerance.

4.6 *Insulation resistance (insulated styles only)*

4.6.1 The test shall be performed using one of the following three methods as prescribed in the relevant detail specification. The V-block method is the preferred method for resistors without mounting devices.

4.6.1.1 *V-block method*

The resistor shall be clamped in the trough of a 90° metallic V-block of such size that the resistor body does not extend beyond the extremities of the block.

The clamping force shall be such as to guarantee adequate contact between the resistor and the block. The clamping force is to be chosen in such a way that no destruction or damage to the resistor occurs.

The resistor shall be positioned in accordance with the following:

- for cylindrical resistors: the resistor shall be positioned in the block so that the termination furthest from the axis of the resistor is nearest to one of the faces of the block;
- for rectangular resistors: the resistor shall be positioned in the block so that the termination nearest to the edge of the resistor is nearest to one of the faces of the block;

For cylindrical and rectangular resistors with axial leads: any out-of-centre positioning of the point of emergence of the terminations from the body shall be ignored.

4.6.1.2 *Foil method*

(Alternative method for resistors without mounting devices.) A metal foil shall be wrapped closely around the body of the resistor.

For resistors not having axial terminations, a space of 1 to 1.5 mm shall be left between the edge of the foil and each termination.

For resistors having axial terminations, the foil shall be wrapped around the whole body of the resistor protruding by at least 5 mm from each end, provided that the minimum space of 1 mm between the foil and the termination can be maintained. The ends of the foil shall not be folded over the ends of the resistor.

4.6.1.3 *Method for resistors with mounting devices*

The resistor shall be mounted in its normal manner on a metal plate (or between two metal plates) which extends at least 12.7 mm (0.5 in) in all directions beyond the mounting face of the resistor.

4.6.2 The insulation resistance shall be measured between both terminations of the resistor connected together as one pole and the V-block or the metal foil or mounting devices, as the other pole. The measuring voltage shall be either 100 ± 15 V d.c. for resistors with an isolation voltage <500 V or 500 ± 5 V d.c. for resistors with an isolation voltage $\geqq 500$ V.

The voltage shall be applied for 1 min or for such shorter time as is necessary to obtain a stable reading; the insulation resistance shall be read at the end of that period.

4.6.3 The insulation resistance shall be not less than that prescribed in the relevant specification.

4.7 *Voltage proof*

4.7.1 The test shall be performed using one of the methods specified in Sub-clause 4.6.1, as prescribed in the relevant specification.

The V-block method is the preferred method for resistors without mounting devices.

4.7.2 The test voltage shall be applied between the terminations of the resistor connected together as one pole, and the V-block or metal foil or mounting plate(s) as the other pole. The test voltage shall be alternating (40 Hz to 60 Hz) and shall be increased, at a rate of about 100 V/s, from zero to a peak value of 1.42 times the value of the isolation voltage specified in the detail specification. After the specified voltage has been reached, the voltage shall continue to be applied for 1 min ± 5 s.

4.7.3 There shall be no breakdown or flash-over.

4.8 *Variation of resistance with temperature*

4.8.1 The resistor shall be dried using either Procedure I or Procedure II of Sub-clause 4.3, as prescribed in the relevant specification.

4.8.2 The resistor shall be maintained at each of the following temperatures in turn or at other temperatures specified in the relevant specification:

a) 20^{+5}_{-1} °C

b) lower category temperature ±3 °C

c) 20^{+5}_{-1} °C

d) upper category temperature ±2 °C

e) 20^{+5}_{-1} °C

4.8.3 Resistance measurements shall be made at each of the temperatures specified in Sub-clause 4.8.2 after the resistor has reached thermal stability.

The condition of thermal stability is judged to be reached when two readings of resistance taken at an interval of not less than 5 min do not differ by an amount greater than that which can be attributed to the measuring apparatus.

The temperature of the resistor at the time of measurement shall be recorded. The error of measurement of temperature shall not exceed 1 °C.

4.8.4 *Methods of calculation*

Note. — Results of one measurement may be used for the calculation of the temperature coefficient and for the calculation of the temperature characteristic.

4.8.4.1 *Temperature characteristic of resistance*

The temperature characteristic of resistance between 20 °C and each of the other temperatures specified in Sub-clause 4.8.2 shall be calculated from the following formula:

$$\text{Temperature characteristic of resistance} = A \cdot \frac{\Delta R}{R}$$

where, if the resistances recorded in Sub-clause 4.8.3 are designated R_a, R_b, R_c, R_d and R_e, R and ΔR are given as shown in the table below:

	Lower category temperature	Upper category temperature
R ΔR	$\frac{1}{2}(R_a+R_c)$ R_b-R	$\frac{1}{2}(R_c+R_e)$ R_d-R

and where:

$$A = \frac{\text{difference between nominal specified temperatures}}{\text{difference between recorded temperatures}}$$

If the temperatures recorded in Sub-clause 4.8.3 are designated θ_a, θ_b, θ_c, θ_d and θ_e, the temperature differences ($\Delta\theta$) between recorded temperatures are given as shown in the table below:

θ	Lower category temperature	Upper category temperature
$\Delta\theta$	$\theta_b-\frac{\theta_a+\theta_c}{2}$	$\theta_d-\frac{\theta_c+\theta_e}{2}$

4.8.4.2 *Temperature coefficient of resistance* (α)

The temperature coefficient of resistance (α) between 20 °C and each of the other temperatures specified in Sub-clause 4.8.2 shall be calculated from the following formula:

$$\alpha = \frac{\Delta R}{R \cdot \Delta\theta}$$

For R, ΔR and $\Delta\theta$ see Sub-clause 4.8.4.1.

The temperature coefficient of resistance (α) is normally expressed in parts per million per degree Celsius (10^{-6}/°C).

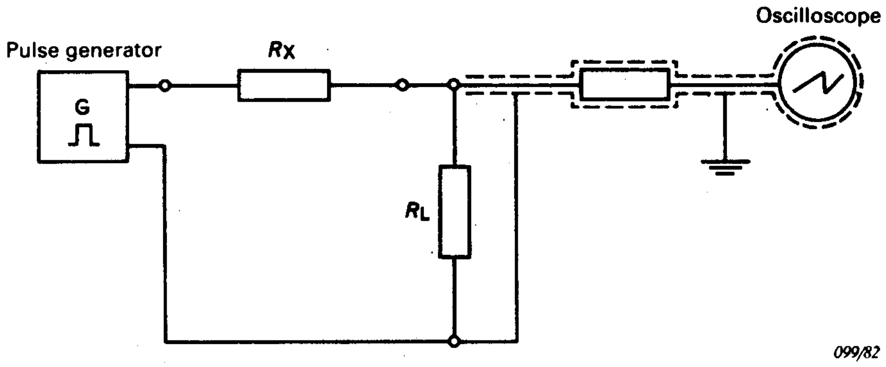
4.8.5 The temperature characteristic of resistance or the temperature coefficient of resistance (α), ascertained as described above shall be within the limits prescribed in the detail specification for the appropriate category temperature.

When the resistance value is greater than 5Ω but less than 10Ω the temperature characteristic or temperature coefficient shall not exceed the limits prescribed in the detail specification for values equal to or above 10Ω by more than a factor of 2.

Note. — The temperature characteristic or temperature coefficient of resistance is not specified for resistance values of less than 5 Ω owing to difficulty of accurate measurement.

4.9 *Reactance*

4.9.1 The reactance test is applicable only to resistors for which a low reactance is required and is specified in the detail specification. It is a suitable test for inductance in the range exhibited by wirewound resistors. The instrumentation shown in Figure 1 can be used for resistors with L/R time constant >20 ns. The resistance range which can be tested is from 100 Ω to 1 MΩ.



R_X = resistor under test
R_L = non-inductive resistor with resistance approximately equal to 0.1 times the resistance of R_X

FIG. 1. — Test circuit.

The length of the connecting leads between the generator and the resistor R_X shall not exceed 50 mm (2 in).

4.9.2 *Pulse generator specification*

a) Pulse width: sufficient to cover three times L/R period.

b) Rise time on load (10% to 90%): less than 3 ns.

c) Repetition rate: greater than 10 kHz, or that required to obtain good oscilloscope readability.

4.9.3 *Oscilloscope specification*

a) Rise time (10% to 90%): less than 12 ns (frequency response, 30 MHz or better).

b) Time base: 2 ns per mm or faster.

c) Input capacitance at R_L should be 25 pF or less.

d) Amplification shall be sufficient to obtain good readability with the pulse voltage used.

4.9.4 The L/R time constant is determined by measuring the time between the start of the pulse and the time the voltage attains 63.2% of the maximum (see Figure 2, page 39). If there is noise or distortion at the start of the rise, the zero point can be determined by extension of the curve. If there is no overshoot or oscillation and the L/R time is greater than 20 ns, then the formula below can be used with sufficient accuracy:

Effective inductance (H) $= L/R(\text{s}) \times R(\Omega)$.

Note. A specification limit could be set either as a maximum L/R time, or resulting from use of the calculation, as a maximum inductance.

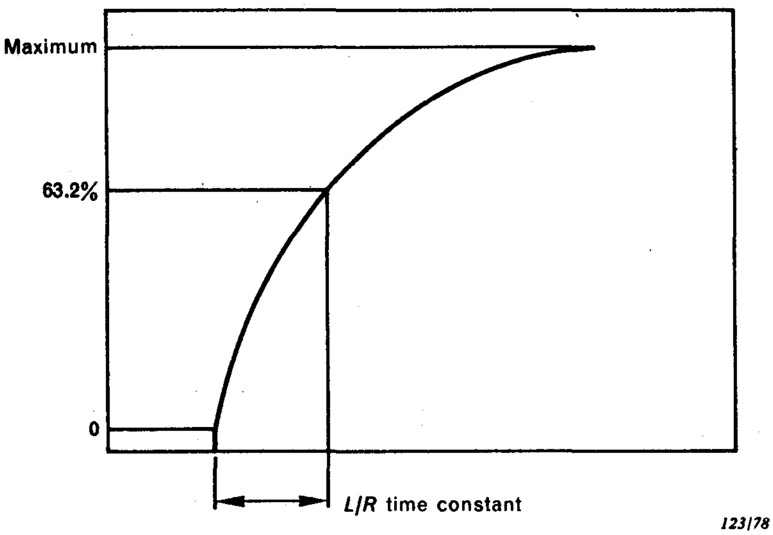


FIG. 2. — Oscilloscope trace.

4.10 *Non-linear properties*

The resistors shall be measured for non-linearity in accordance with I E C Publication 440. When there are specific requirements for non-linearity, they shall be specified in the detail specification.

4.11 *Voltage coefficient*

(Applicable only when prescribed in the detail specification or when agreed upon between manufacturer and customer.)

4.11.1 The resistor shall be dried using either Procedure I or Procedure II of Sub-clause 4.3, as prescribed in the relevant specification.

4.11.2 The resistance shall then be measured at 10% and at 100% of either the rated voltage or the limiting element voltage, whichever is the smaller. The 100% voltage shall be applied for not more than 0.5 s in every 5 s; the 10% voltage shall be applied for 4.5 s. Care shall be taken that there is no appreciable temperature rise of the resistor.

4.11.3 The voltage coefficient is normally expressed in percent per volt and shall be calculated from the following formula:

$$\text{voltage coefficient: } \frac{(R_2 - R_1)}{0.9\, U R_1}$$

where:

U is the higher applied voltage
R_1 is the resistance measured at 0.1 U
R_2 is the resistance measured at U

4.11.4 The value of the voltage coefficient shall not exceed that prescribed in the relevant specification.

4.12 *Noise*

(Applicable only when prescribed in the detail specification or when agreed upon between manufacturer and customer.)

The resistors shall be subjected to the procedure given in I E.C Publication 195.

4.13 *Overload*

4.13.1 The resistance shall be measured as specified in Sub-clause 4.5.

4.13.2 The resistor shall be mounted horizontally. For wirewound resistors, the axis of the winding shall be horizontal. The resistor shall be in free air at an ambient temperature of between 15 °C and 35 °C. A voltage shall then be applied to the terminations of the resistor. The value of the voltage and the duration of its application shall be as prescribed in the relevant specification. Connections shall be made in the usual manner. For resistors with soldering tags, copper wire of approximately 1.0 mm (0.040 in) diameter shall be used for connecting the resistors. The relevant specification shall prescribe any special mounting arrangements.

4.13.3 After recovery of not less than 1 h nor more than 2 h, the resistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

4.13.4 The resistance shall then be measured as specified in Sub-clause 4.5. The change of resistance, with respect to the value measured in Sub-clause 4.13.1, shall not exceed the value prescribed in the relevant specification.

4.14 *Temperature rise*

4.14.1 Resistors having a rated resistance less than the critical resistance value shall be subjected to the following test.

4.14.2 The resistor shall be mounted horizontally. For wirewound resistors, the axis of the winding shall be horizontal. Connections shall be made in the usual manner. For resistors with soldering tags, copper wire of approximately 1.0 mm (0.040 in) diameter shall be used for connecting the resistors. The relevant specification shall prescribe any special mounting arrangements.

4.14.3 The ambient temperature for the test shall be 15 °C to 35 °C. There shall be no air circulation other than that produced by natural convection caused by the heated resistor.

4.14.4 The rated voltage shall be applied.

4.14.5 The temperature at the hottest point on the surface of the resistor shall be measured after temperature equilibrium has been attained. The temperature measuring device shall be of such dimensions as not to affect the result of the measurement.

4.14.6 The temperature rise shall not exceed the value prescribed in the detail specification.

Note. — A more precise procedure for surface temperature measurement is under consideration.

4.15 *Robustness of the resistor body*

4.15.1 Resistors having a body length not less than 25 mm shall be subjected to the following test.

4.15.2 The body of the resistor is supported at both ends, the distance of the supports from the end faces being not more than 5 mm (0.2 in). The support shall have a radius of not less than 6 mm (0.24 in). A thrust as prescribed in the detail specification is applied gradually to the centre of the body in a direction perpendicular to the axis for a period of 10 s. The load shal be applied through a device having a radius of not less than 6 mm (0.24 in) (see Figure 3).

4.15.3 At the conclusion of this test, the body of the resistor shall not be cracked or broken..

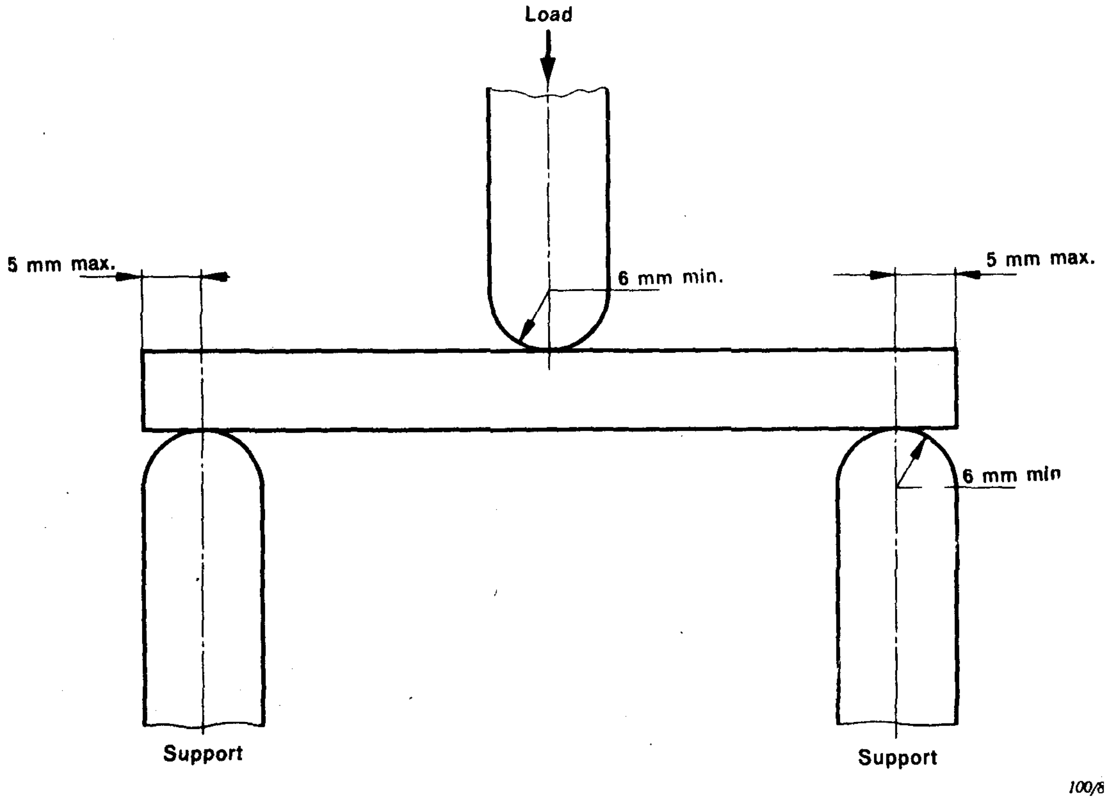


FIGURE 3

4.16 *Robustness of terminations*

The resistors shall be subjected to Tests Ua_1, Ub, Uc and Ud of IEC Publication 68 (1975), as applicable.

4.16.1 The resistance shall be measured as specified in Sub-clause 4.5.

4.16.2 *Test Ua_1 — Tensile*

The force applied shall be:

— for terminations other than wire terminations: 20 N,

— for wire terminations see table below:

Nominal cross-sectional area (mm²)	Corresponding diameter for circular-section wires (mm)	Force (N)
$S \leqq 0.05$	$d \leqq 0.25$	1
$0.05 < S \leqq 0.07$	$0.25 < d \leqq 0.3$	2.5
$0.07 < S \leqq 0.2$	$0.3 < d \leqq 0.5$	5
$0.2 < S \leqq 0.5$	$0.5 < d \leqq 0.8$	10
$0.5 < S \leqq 1.2$	$0.8 < d \leqq 1.25$	20
$1.2 < S$	$1.25 < d$	40

4.16.3 *Test Ub — Bending (half of the number of terminations)*

Method 1: Two consecutive bends shall be applied in each direction. This test shall not apply if in the detail specification the terminations are described as rigid.

4.16.4 *Test Uc — Torsion (other half of the number of terminations)*

Method A, severity 2 (two successive rotations of 180°) shall be used.

This test shall not apply if in the detail specification the terminations are described as rigid and to components with unidirectional terminations designed for printed wiring applications.

4.16.5 *Test Ud — Torque (for terminations with threaded studs or screws and for integral mounting devices)*

Nominal thread diameter (mm)		2.6	3	3.5	4	5	6
Torque (N·m)	Severity 1	0.4	0.5	0.8	1.2	2.0	2.5
	Severity 2	0.2	0.25	0.4	0.6	1.0	1.25

4.16.6 *a)* After each of these tests, the resistors shall be visually examined. There shall be no visible damage.

b) At the conclusion of the last of these tests the resistance shall then be measured as specified in Sub-clause 4.5. The change of resistance with respect to the value measured in Sub-clause 4.16.1 shall not exceed the value prescribed in the relevant specification.

4.17 *Solderability*

4.17.1 When the solderability test is followed immediately by the resistance to soldering heat test, a drying procedure as prescribed in Sub-clause 4.3 shall be applied. The detail specification shall prescribe whether Procedure I or Procedure II shall be used.

4.17.2 Resistors shall be subjected to Test T of IEC Publication 68-2-20 (1968) either using the solder bath method (Method 1) or the soldering iron method (Method 2) or the solder globule method (Method 3) as prescribed by the relevant specification.

4.17.3 When the solder bath method (Method 1) is specified, the following requirements apply:

4.17.3.1 *Test conditions*

a) All resistors, except those of *b)* below:

Bath temperature: 230 ± 10 °C
Immersion time: 2 ± 0.5 s
Depth of immersion (from the seating plane or component body): $2^{+0}_{-0.5}$ mm

b) Resistors indicated by the detail specification as being not designed for use on printed boards:

Bath temperature: 270 ± 10 °C
Immersion time: 2 ± 0.5 s
Depth of immersion (from the component body): 6^{+1}_{-0} mm

4.17.3.2 The terminations shall be examined for good tinning as evidenced by free flowing of the solder with wetting of the terminations.

4.17.4 When the solder bath method is not applicable, the detail specification shall define the test method, test conditions and the requirements.

Note. — When the solder globule method is used, the requirements shall include the soldering time.

4.18 *Resistance to soldering heat*

4.18.1 If drying is called for in the detail specification it shall be stated whether Procedure I or Procedure II of Sub-clause 4.3 shall be used.

When the resistance to soldering heat test is to be applied immediately after the solderability test, the drying procedure may be performed prior to the solderability test. The resistance shall then be measured as specified in Sub-clause 4.5.

4.18.2 The resistors shall then be subjected to one of the procedures for resistance to soldering heat of Test Tb of I E C Publication 68-2-20A (1970) as prescribed in the relevant specification.

4.18.3 After recovery the resistors shall be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance shall be measured as specified in Sub-clause 4.5, 24 ± 4 h after the test, unless it can be demonstrated that stability is reached earlier.

The change of resistance with respect to the value measured in Sub-clause 4.18.1 shall not exceed the limit prescribed in the relevant specification.

4.19 *Rapid change of temperature*

4.19.1 The resistance shall be measured as specified in Sub-clause 4.5.

4.19.2 The resistors shall be subjected to Test Na of IEC Publication 68-2-14 (1974) for five cycles. Unless otherwise specified in the relevant specification the duration of the exposure at each of the extremes of temperature shall be 30 min.

The resistors shall then remain under standard atmospheric conditions for recovery for not less than 1 h nor more than 2 h.

4.19.3 After recovery, the resistors shall be visually examined. There shall be no visible damage.

The resistance shall be measured as specified in Sub-clause 4.5. The change of resistance with respect to the value measured in Sub-clause 4.19.1 shall not exceed the limit prescribed in the relevant specification.

4.20 *Bump*

4.20.1 The resistor shall be mounted as indicated in the relevant specification.

4.20.2 The resistance shall be measured as specified in Sub-clause 4.5.

4.20.3 The resistors shall be subjected to Test Eb of IEC Publication 68-2-29 (1968) using the degree of severity prescribed in the relevant specification.

4.20.4 After the test, the resistors shall be visually examined. There shall be no visible damage.

The resistance shall be measured as specified in Sub-clause 4.5. The change of resistance with respect to the value measured in Sub-clause 4.20.2 shall not exceed the limit prescribed in the relevant specification.

4.21 *Shock*

4.21.1 The resistor shall be mounted as indicated in the relevant specification.

4.21.2 The resistance shall be measured as specified in Sub-clause 4.5.

4.21.3 The resistors shall be subjected to Test Ea of IEC Publication 68-2-27 (1972) using the degree of severity prescribed in the relevant specification.

4.21.4 When prescribed in the detail specification, measurement of resistance shall be made at intervals during the test as prescribed in the relevant specification.

4.21.5 After the test, the resistors shall be visually examined. There shall be no visible damage.

The resistance shall be measured as specified in Sub-clause 4.5. The change of resistance with respect to the value measured in Sub-clause 4.21.2 shall not exceed the limit prescribed in the relevant specification.

4.22 *Vibration*

4.22.1 The resistor shall be mounted as indicated in the relevant specification.

4.22.2 The resistance shall be measured as specified in Sub-clause 4.5.

4.22.3 Unless othetwise prescribed by the relevant specification, the resistors shall be subjected to Method B4 of Test Fc of IEC Publication 68-2-6 (1970) using the degree of severity prescribed in the relevant specification.

When specified in the detail specification, during the last thirty minutes of the vibration test in each direction of movement, an electrical measurement shall be made to check intermittent contacts or open or short circuit. The duration of the measurement shall be the time needed for one sweep of the frequency range from one frequency extreme to the other.

4.22.4 After the test, the resistor shall be visually examined. There shall be no visible damage. When the resistors are tested as specified in Sub-clause 4.22.3, there shall be no intermittent contact greater than or equal to 0.5 ms, nor open or short circuit.

The resistance shall be measured as specified in Sub-clause 4.5. The change of resistance with respect to the value measured in Sub-clause 4.22.2 shall not exceed the limit prescribed in the relevant specification.

4.23 *Climatic sequence*

In the climatic sequence, an interval of 3 days maximum is permitted between any of the tests, except that the cold test shall be applied immediately after the recovery period specified for the first cycle of the damp heat, cyclic, Test Db.

4.23.1 *Initial measurements*

a) The resistors shall be dried using either Procedure I or Procedure II of Sub-clause 4.3 as prescribed in the relevant specification.

b) The resistance shall be measured as specified in Sub-clause 4.5.

4.23.2 *Dry heat*

The resistors shall be subjected to Test Ba of IEC Publication 68-2-2 (1974), at the upper category temperature for a duration of 16 h.

4.23.3 *Damp heat, cyclic, Test Db, first cycle*

The resistors shall be subjected to Test Db of IEC Publication 68-2-30 (1969) for one cycle of 24 h, using a temperature of 55 °C (Severity *b*).

4.23.4 *Cold*

The resistors shall be subjected to Test Aa of IEC Publication 68-2-1 (1974) at the lower category temperature for a duration of 2 h.

4.23.5 *Low air pressure*

a) The resistors shall be subjected to Test M of IEC Publication 68-2-13 (1966), using the degree of severity prescribed in the relevant specification.

b) The test shall be carried out at a temperature of between 15 °C and 35 °C. The duration of the test shall be 1 h.

4.23.6 *Damp heat, cyclic, Test Db, remaining cycles*

The resistors shall be subjected to Test Db of I E C Publication 68-2-30 (1969) for the following cycles of 24 h as indicated in the table below, at a temperature of 55 °C (Severity *b*).

Categories	Number of cycles
-/-/56	5
-/-/21	1
-/-/10	1
-/-/04	none

4.23.7 *D.C. load (applicable only to non-wirewound resistors)*

At the end of the test, the resistors shall be subjected to the standard atmospheric conditions for testing. The time of transfer shall be as short as possible and shall not exceed 5 min. At 30 ± 5 min after removal from the chamber, the resistors shall be subjected to a d.c. voltage for one minute. The voltage shall be the rated voltage, or the limiting element voltage, whichever is the smaller. The resistors shall then remain in the standard atmospheric conditions for testing for not less than 1 h and not more than 2 h.

4.23.8 The resistor shall then be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance and (for insulated resistors only) the insulation resistance shall then be measured as specified. The change of resistance with respect to the value measured in Sub-clause 4.23.1*b* shall not exceed the value prescribed in the relevant specification.

The insulation resistance shall be not less than that prescribed in the relevant specification.

4.24 *Damp heat, steady state*

4.24.1 The resistance shall be measured as specified in Sub-clause 4.5.

4.24.2 The resistors shall be subjected to Test Ca of I E C Publication 68-2-3 (1969) using the degree of severity corresponding to the climatic category of the resistor as indicated in the relevant specification.

4.24.2.1 For insulated resistors or for those which are normally mounted on or between metal plates with or without additional insulation, the resistors shall be divided into three groups:

a) The first group shall be subjected to this test without voltage applied.

b) The second group shall be subjected to the test with a direct voltage between the terminations. The voltage to be applied shall be selected from the following series:

0, 4, 6.3, 10, 16, 25, 40, 63 and 100 V

The voltage selected shall be the next lower value to that derived from a calculation of the voltage required so that the resistor is dissipating 0.01 times the rated dissipation, or shall be 0.1 times the limiting element voltage, whichever is the smaller. Throughout the test period the voltage shall be kept as close as possible to the specified voltage, a tolerance of ±5% is allowed for mains voltage fluctuations and similar factors.

c) The third group shall be subjected to the test with a direct voltage of 20 ± 2 V applied between the mounting plates and one of the terminations. The mounting plates are connected to the negative pole and the termination to the positive pole of the voltage source. The voltage shall be applied continuously throughout the test.

4.24.2.2 For all other resistors, the lot shall be divided into two groups and only the tests *a)* and *b)* of Sub-clause 4.24.2.1 shall be carried out.

4.24.3 *D.C. load (applicable only to non-wirewound resistors)*

At the end of the test, the resistors shall be subjected to the standard atmospheric conditions for testing. The time of transfer shall be as short as possible and shall not exceed 5 min. At 30±5 min after removal from the chamber, the resistors shall be subjected to a d.c. voltage for one minute. The voltage shall be the rated voltage or the limiting element voltage, whichever is the smaller. The resistors shall then remain in the standard atmospheric conditions for testing for not less than 1 h and not more than 2 h.

4.24.4 The resistors shall then be visually examined. There shall be no visible damage and the marking shall be legible.

The resistance and (for insulated resistors only) the insulation resistance shall then be measured as specified. The change of resistance with respect to the value measured in Sub-clause 4.24.1 shall not exceed the value prescribed in the relevant specification.

The insulation resistance shall be not less than that prescribed in the relevant specification.

4.25 *Endurance*

The rated dissipation shall always be given with reference to an ambient temperature of 70 °C and shall be verified by means of the endurance test at 70 °C or, in the case of certain high-power resistors, the endurance test at room temperature using the correction factor given in Sub-clause 4.25.2.3.

When changes in the slope of the derating curve occur at temperatures other than 70 °C, one of the following additional procedures shall apply:

1) At temperatures lower than 70 °C (e.g. where a resistor is derated linearly from 20 °C, through 70 °C, to zero dissipation at the upper category temperature, or where a resistor has constant dissipation from 20 °C to 40 °C and is then derated linearly from 40 °C, through 70 °C to zero dissipation at the upper category temperature) the resistors shall be subjected to the conditions specified in Sub-clause 4.25.1 (endurance at 70 °C) except that:

   a) the test temperature shall be that at which the change of the slope of the derating curve occurs;

   b) the voltage to be applied shall be that calculated from the square root of the product of the rated resistance and the dissipation at test temperature or it shall be the limiting element voltage, whichever is the smaller. The test dissipation shall be calculated using the following formula:

$$P_t = P_R + (P_R - P_C)\,\frac{70 - \theta_t}{\theta_{UC} - 70}$$

where:

P_t = dissipation at test temperature
P_R = rated dissipation
P_C = category dissipation
} in watts

θ_t = test temperature
θ_{UC} = upper category temperature
} in degrees Celsius

2) At temperatures higher than 70 °C (e.g. when a resistor maintains its rated dissipation constant from 20 °C, through 70 °C, to (say) 125 °C and then is derated linearly to either zero dissipation or the category dissipation at the upper category temperature) the resistors shall be subjected to the conditions specified in Sub-clause 4.25.1 (endurance at 70 °C) except that the test temperature shall be that at which the change in the slope of the derating curve occurs.

The requirements for intermediate and final measurements in 1) and 2) above shall be the same as those specified in the relevant specification for the endurance test used to verify the rated dissipation.

4.25.1 *Endurance at 70 °C*

4.25.1.1 The resistors shall be measured as specified in Sub-clause 4.5.

4.25.1.2 The resistance shall be subjected to an endurance test of 42 days (1 000 h) at an ambient temperature of 70 ± 2 °C. The relevant specification may specify an extended duration of the test (see Sub-clause 4.25.1.8).

4.25.1.3 Resistors with a rated dissipation equal to or less than 15 W shall be tested with a direct voltage. Any ripple voltage shall not exceed 5% (peak-to-peak).

Resistors with a rated dissipation greater than 15 W shall be tested with an alternating voltage.

The voltage shall be applied in cycles of 1.5 h on and 0.5 h off throughout the test. This voltage shall be the rated voltage or the limiting element voltage whichever is the smaller.

The applied voltage shall be within ± 5% of this voltage.

Note. — The half-hour off-periods are included in the total test duration specified in Sub-clause 4.25.1.2.

4.25.1.4 The resistors shall be connected by their terminations to suitable clips on a rack of insulating material. All resistors shall be mounted in a horizontal position, in one layer only, unless otherwise specified in the sectional specification. The distance between the axes of the resistor shall be not less than seven times the diameter of the resistors. There shall be no undue draught over the resistors. If forced air circulation is used in the test chamber, the resistors shall be protected so that there is no draught, other than by natural convection, over the resistors.

4.25.1.5 The size of the testing chamber and the number of resistors under test shall be such that when all resistors are fully loaded, the heat produced by them shall be less than that required to maintain the atmosphere in the chamber at 70 °C so that the temperature can still be controlled by the heating element. The temperature controlling elements shall be suitably spaced from the resistors and shall be shielded so as not to be directly influenced by the radiation of the resistors. It shall be assumed in this test that the ambient temperature of the resistors is 70 °C.

4.25.1.6 After approximately 48 h, 500 h and 1000 h, the resistors shall be removed from the chamber and allowed to recover under standard atmospheric conditions for testing for not less than 1 h and not more than 4 h. The removal from the chamber shall take place at the end of the half-hour off-period.

Alternatively, resistance change measurements may be made at test temperature and the marking shall be legible. In that case, at the beginning of the test an additional resistance measurement at test temperature for reference purposes has to be made. However initial and final measurements shall always be made under standard atmospheric conditions for testing.

Note. — For a particular specimen, the same procedure shall always apply.

4.25.1.7 The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible. The resistance shall be measured as specified in Sub-clause 4.5 and the change in resistance with respect to the value measured in Sub-clause 4.25.1.1 in each of the succeeding measurements shall not exceed the value prescribed in the relevant specification.

After intermediate measurements the resistors shall be returned to the test chamber. The interval between the removal of any resistor from the chamber and its return to the chamber shall not exceed 12 h.

After 1000 h, the insulation resistance shall be measured (insulated resistors only) and the value shall be not less than that prescribed in the relevant specification.

4.25.1.8 When prescribed by the relevant specification, the duration of the test shall be extended by a specified period. For this period the relevant specification shall specify the time at which any measurements shall be made and the requirements.

4.25.2 *Endurance at room temperature*

4.25.2.1 The resistance shall be measured as specified in Sub-clause 4.5.

4.25.2.2 The resistors shall be subjected to an endurance test of 42 days (1000 h) at an ambient temperature of between 15 °C and 35 °C. When required by the detail specification, the duration of the test may be extended (see Sub-clause 4.25.2.7).

4.25.2.3 Resistors with a rated dissipation equal to or less than 15 W shall be tested with a direct voltage. Any ripple voltage shall not exceed 5%.

Resistors with a rated dissipation greater than 15 W shall be tested with an alternating voltage. However, resistors specifically designed for d.c. application (and described as such in their detail specification) shall be tested with a direct voltage.

When resistors specifically designed for d.c. application are allowed to have a surface temperature that exceeds the ambient temperature by more than 200 °C the test duration shall be extended to 3000 h or 5000 h, as prescribed by the detail specification. In this case the voltage shall be applied with the same polarity during the total test duration.

The voltage shall be applied in cycles of 1.5 h on and 0.5 h off throughout the test.

The voltage shall be the rated voltage multiplied by the square root of the correction factor, or it shall be the limiting element voltage, whichever is the smaller.

The correction factor is:

$$\frac{\text{maximum surface temperature} - \text{test temperature (ambient)}}{\text{maximum surface temperature} - 70\,^{\circ}\text{C}}$$

The voltage applied to the resistors shall be within ±5% of the calculated voltage.

Note. — The half-hour off-periods are included in the total test duration specified in Sub-clause 4.25.2.2.

4.25.2.4 The resistors shall be connected by their terminations to suitable clips on a rack of insulating material. Half the number of the resistors shall be mounted in a horizontal position and the other half in a vertical position. The resistors shall be mounted in one layer only. The distance between the axes of the resistors shall be not less than seven times the diameter of the resistors. There shall be no undue draught over the resistors If forced air circulation is used in the test chamber, the resistors shall be protected so that there is no draught, other than by natural convection, over the resistors.

4.25.2.5 After approximately 48 h, 500 h and 1000 h the resistors shall be removed from the chamber and allowed to recover under standard atmospheric conditions for testing for not less than 1 h and not more than 4 h.

4.25.2.6 The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible. The resistance shall be measured as specified in Sub-clause 4.5 and the change of resistance with respect to the value measured in Sub-clause 4.25.2.1 shall not exceed the value prescribed in the relevant specification.

After intermediate measurements, the resistors shall be returned to the test chamber. The interval between the removal of any resistor from the chamber and its return to the chamber shall not exceed 12 h.

After 1000 h, the insulation resistance shall be measured (insulated resistors only) and the value shall be not less than that prescribed in the relevant specification.

4.25.2.7 When prescribed by the relevant specification, the duration of the test shall be extended by a specified period. For this period, the relevant specification shall specify the time at which any measurement shall be made and the requirements.

4.25.3 *Endurance at the upper category temperature*

4.25.3.1 The resistance shall be measured as specified in Sub-clause 4.5.

4.25.3.2 The resistors shall be subjected to an endurance test of 42 days (1000 h), at an ambient temperature equal to the upper category temperature prescribed in the relevant specification. When required by the detail specification, the duration of the test may be extended (see Sub-clause 4.25.3.8).

For those resistors which are derated to zero at temperatures of 200 °C and below, the test shall be performed at zero dissipation. For those resistors which are derated to zero above 200 °C, the test shall be performed at 200 °C with that portion of their rated dissipation applicable at 200 °C (category dissipation).

4.25.3.3 Resistors with a rated dissipation equal to or less than 15 W shall be tested with a direct voltage. Any ripple voltage shall not exceed 5%. Resistors with a rated dissipation greater than 15 W shall be tested with an alternating voltage.

The voltage shall be applied in cycles of 1.5 h on and 0.5 h off throughout the test.

The voltage shall be the limiting element voltage or the voltage calculated from the category dissipation and the rated resistance, whichever is the less.

The applied voltage shall be within ±5% of this voltage.

Note. — The half-hour off-periods are included in the total test duration specified in Sub-clause 4.25.3.2.

4.25.3.4 When the resistors are dissipating power, they shall be mounted in the same manner as specified in Sub-clauses 4.25.1.4 or 4.25.2.4 as appropriate.

There shall be no undue draught over the resistors. If forced air circulation is used in the test chamber, the resistors shall be protected so that there is no draught, other than by natural convection, over the resistors.

4.25.3.5 The size of the testing chamber and the number of resistors under test shall be such that when all resistors are fully loaded the heat produced by them shall be less than that required to maintain the atmosphere in the chamber at the upper category temperature so that the temperature can still be controlled by the heating elements. The temperature controlling elements shall be suitably spaced from the resistors and shall be shielded so as not to be directly influenced by the radiation of the resistors. It shall be assumed in this test that the ambient temperature of the resistors is the same as the upper category temperature.

4.25.3.6 After approximately 48 h, 500 h and 1000 h, the resistors shall be removed from the chamber and allowed to recover under standard atmospheric conditions for testing for not less than 1 h and not more than 4 h. The removal from the chamber shall take place at the end of the half-hour off-period for those resistors which are dissipating power.

4.25.3.7 The resistors shall be visually examined. There shall be no visible damage and the marking shall be legible. The resistance shall be measured as specified in Sub-clause 4.5. The change of resistance with respect to the value measured in Sub-clause 4.25.3.1 in each of the succeeding measurements shall not exceed the value prescribed in the relevant specification for the corresponding endurance test at 70 °C (Sub-clause 4.25.1) or at room temperature (Sub-clause 4.25.2).

After intermediate measurements the resistors shall be returned to the test chamber. The interval between the removal of any resistor from the chamber and its return to the chamber shall not exceed 12 h.

After 1000 h, the insulation resistance shall be measured (insulated resistors only) and the value shall be not less than that prescribed in the relevant specification.

4.25.3.8 When prescribed by the relevant specification, the duration of the test shall be extended by a specified period. For this period the relevant specification shall specify the time at which any measurements shall be made and the requirements.

4.26 *Accidental overload test (for low power non-wirewound resistors only)*

4.26.1 *Object*

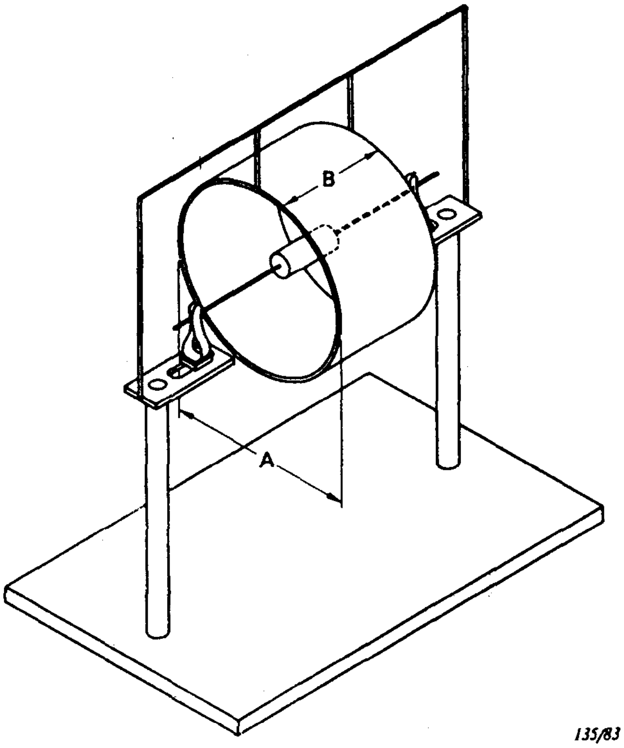
To assess the fire hazard, resulting from the application of overload to a resistor.

4.26.2 *Test method (gauze cylinder method)*

The test fixture shall consist of a single layer gauze cylinder around the specimen under test at a distance of 25 ± 3 mm (1 ± 1/8 in) from the body.

A single layer of cheese-cloth shall be placed around an internal framework to form a cylinder (see Figure 4) with open ends.

The internal framework shall be constructed from cylindrical wire with a diameter ⩽ 0.6 mm (22 AWG); copper wire shall not be used. The framework wires shall be equally spaced throughout the cylinder and shall not cover more than 10% of the gauze cylinder.



A is 50 ± 1.5 mm (2 ± 1/16 in) larger diameter than the component diameter.
B is not less than two times the length of the component under test.

FIG. 4. — Gauze cylinder fixture.

The length of the cylinder shall be not less than two times the length of the body of the specimen under test.

The cheese-cloth used in the forming of the cylinder shall be untreated pure cotton cloth with a mass of 36.3 to 38.8 g/m² and having what is known as a count of 32 × 28.

Note. — In the original publication from which these dimensions were taken they were described as follows: "The cheese-cloth used in the forming of the cylinder shall be untreated cotton cloth, the type described as 36 inches wide, running 14-15 yards per pound and having what is known as a count of 32 by 28".

The cheese-cloth shall be pre-conditioned under standard atmospheric conditions for testing for 24 h.

The test specimen shall be placed in the fixture so that the gauze cylinder is centred around the unit under test in both the axial and longitudinal direction.

4.26.3 *Conditions of test*

4.26.3.1 *Ventilation*

This test shall be made in an area which is suitably vented for elimination of smoke and fumes.

The air velocity over the test specimen shall not exceed 30 m per minute.

4.26.3.2. *Mounting clips*

Mounting clips shall be of a light-weight terminal design and shall contact the leads of the component in such a manner that no excessive heat dissipation resulting from the mounting method is affecting the test results.

4.26.4 *Test procedure*

When this test is prescribed by a detail specification, this detail specification shall also specify the resistance range for which this test applies and the resistance range from which the test sample shall be taken.

The resistors shall be connected to a constant a.c. voltage supply at standard atmospheric conditions for testing, unless otherwise specified in the detail specification.

Overloads of 5, 10, 16, 25, 40, 63 and 100 times the rated dissipation shall be applied to the resistors under test, but the applied voltage shall not exceed four times the limiting element voltage, unless otherwise specified in the detail specification.

Each overload shall be applied to a fresh specimen and have a duration of 5 ± 0.5 min or until the resistor becomes open circuit or the gauze cylinder ignites, whichever is the shorter.

During the test the current through each resistor shall be monitored by the measurement of the voltage across a low value resistor in series with the resistor under test. The value of this series resistor shall be $\leqslant 1\% \; R_{test}$.

The voltage across this series resistor is then a measure for the current through R_{test} and shall be observed.

During each overload, the time of occurrence of the following phenomena shall be recorded:

a) Flaming of the gauze cylinder.

b) Low impedance or open circuit (for information only)

4.26.5 *Requirement*

There shall be no flaming of the gauze cylinder.

4.27 *Single-pulse high-voltage overload test*

4.27.1 *Object*

To determine the ability of a resistor to withstand single-pulse conditions of high-voltage overloads occurring occasionally.

This test shows the effect of high-voltage overload on resistor electrical parameters and characteristics.

Note. — It is assumed that the effect of a single pulse has completely disappeared before the next pulse arrives. (See IEC 747-3, Chapter II, Sub-clause 2.1.7.)

4.27.2 *Terminology*

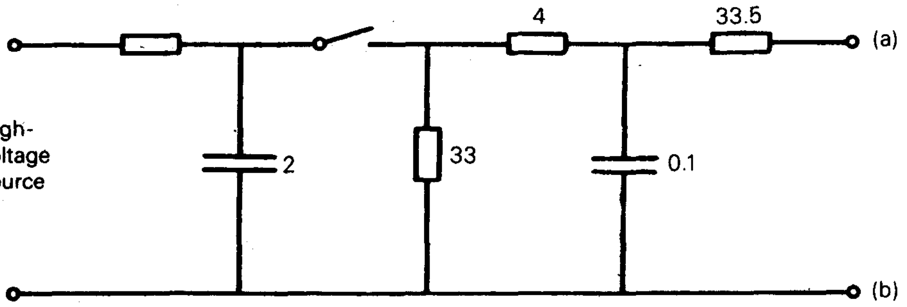
To define the pulse load, the terms and definitions given by IEC Publication 60-1 (First edition 1973) shall apply.

4.27.3 *Test procedure*

Note. — Description of the test equipment.

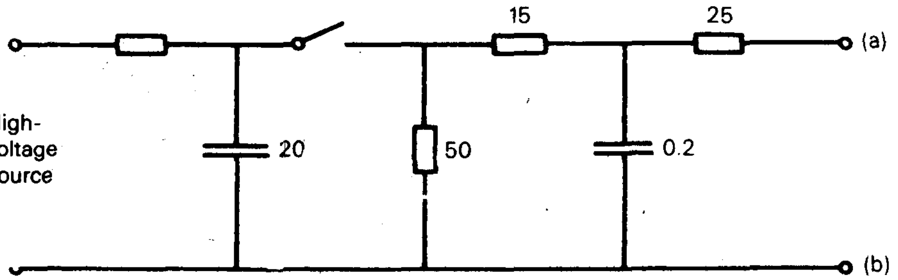
The test equipment shall be able to deliver at least 6 pulses per minute of the required pulse shape into the resistor under test.

The circuit diagrams to achieve the two preferred pulse shapes are shown in Figures 5 and 6.



073/87

FIG. 5. — Pulse generator 1.2/50. ·
Values in µF and in Ω.



074/87

FIG. 6. — Pulse generator 10/700.
Values in µF and in Ω.

Note. — The switch indicated in these figures may be a spark gap or a mechanical switch or a thyristor switch as appropriate with respect to voltage and current.

4.27.4 *Pre-conditioning*

Before the test begins, the resistor shall have attained thermal and humidity equilibrium under standard atmospheric conditions for testing. If required by the detail specification, the resistors shall be dried by using Procedure I of IEC Publication 115-1, Sub-clause 4.3.

4.27.5 *Initial measurements*

Unless otherwise specified, the resistors shall be visually examined and the resistance shall be measured.

4.27.6 *Conditioning*

4.27.6.1 The method of mounting of the resistor shall be specified in the relevant specification.

4.27.6.2 The resistor shall be tested under standard atmospheric conditions for testing.

The test is performed with the test specimens dry and clean at ambient laboratory temperature. The voltage pulse applied shall be based upon the application and shall be selected from Table I.

The pulse test voltage shall be applied to the resistor according to Sub-clause 4.27.6.3 with the appropiate severity as specified in the relevant specification.

4.27.6.3 The resistor under test is connected across (a) and (b) in Figures 1 or 2 respectively. The voltage shall appear across the terminals of the resistor under test. The relevant specification shall give the details.

4.27.7 *Severities*

The test shall be performed with a severity chosen from Table I below:

TABLE I

Severity No.	Pulse shape according to IEC Publication 60-2, Sub-clauses 10.1 or 12 T_1/T_2 µs	Pulse voltage U		Number of pulses per minute	Total number of pulses
		Multiples of U_R*	Multiples of U_{max}*		
1	1.2/50		10	≤6	5
2			15		
3			20		
4	10/1000 or 10/700	10	2	≤1	10
5		20	3		
6		30	4		
7		40	5		
8		50	6		

* whichever is the lower

U_R = Rated voltage; U_{max} = Limiting element voltage

Note. — The given values of pulse voltage are prospective peak voltages as defined in IEC Publication 60-1.

4.27.8 *Recovery*

Recovery shall take place under standard atmospheric conditions for testing until thermal equilibrium has been reached, with a maximum of 24 hours.

4.27.9 *Final inspection, measurements and requirements*

4.27.9.1 The resistors shall be visually examined. There shall be no visible damage. The marking shall be legible.

4.27.9.2 The resistance shall be measured. The change of resistance with respect to the value measured initially (Sub-clause 4.27.5) shall not exceed the limit for the endurance test, unless otherwise specified in the detail specification.

4.27.10 *Information to be given in the detail specification*

a) Method of mounting of the resistor for the test.

b) Test severity, to be selected from Table I.

c) Ambient temperature, if other than 15 °C to 35 °C.

d) Failure criteria, e.g.:
- permissible resistance change if different from that specified for the endurance test;
- insulation breakdown;
- short circuit;
- open circuit;
- other criteria.

4.28 *Periodic pulse high voltage overload test*

4.28.1 *Object*

To determine the ability of a resistor, to withstand conditions of short high overloads occurring periodically (pulse conditions).

Changes in the resistor parameters after the test are basically due to:

- internal voltage effects;
- current effects including local thermal stresses and mechanical forces.

4.28.2 *Terminology*

The following terms and definitions apply:

4.28.2.1 *Pulse duration* (t_p)

The duration between pulse start time and pulse stop time.

4.28.2.2 *Pulse repetition period* (T)

The interval between the pulse start time of a first pulse waveform and the pulse start time of the immediately following pulse waveform in a periodic pulse train.

4.28.2.3. *Nominal pulse voltage*

The steady state value of the voltage shown in Appendix C and designated there by $\hat{U}$.

Note. — $\hat{U}$ may be expressed in multiples of U_R which is the rated voltage on the resistor as defined in IEC Publication 115-1, Sub-clause 2.2.15.

4.28.3 *Test procedure*

4.28.3.1 *Description of the test equipment*

The pulse generator shall be able to produce a continuous sequence of the specified pulse with the specified repetition period over the specified duration of the test. Care has to be taken not to influence one test specimen by another. This may require a separate output stage for each specimen.

A block diagram of a suitable test equipment is given in Appendix C, Figure C1. It consists of a series of power amplifiers with low internal impedance as compared to the resistor under test (voltage source), which can transmit the specified pulse train within the distortion limits given in Figure C2. These amplifiers are fed from a conventional pulse generator delivering the desired waveform, when necessary via further forming, shifting, and driving stages.

To permit the use of a more economical power supply for the driver and power stages in testing many resistors at the same time, it is recommended to drive them sequentially by appropriately phased pulses.

4.28.3.2 *Pre-conditioning*

Before the test begins, the resistors shall have attained thermal and humidity equilibrium under standard atmospheric conditions for testing.

For special applications other pre-conditioning requirements may be given by the relevant specification.

4.28.3.3 *Initial measurements*

Unless otherwise specified the resistors shall be visually examined and the resistance shall be measured.

4.28.3.4 *Conditioning*

The test is performed with unipolar rectangular pulse trains with specified nominal pulse voltage having a specified pulse repetition period and pulse duration.

The method of mounting of the resistor shall be specified in the relevant specification and shall be thermally equivalent to normal endurance testing. The mounting shall not distort the pulse shape outside the limits given in Appendix C, Figure C2.

The resistor shall at a temperature of 25 ± 5 °C (or at such other temperature as may be given in the relevant specification) be subjected to a continuous train of rectangular pulses delivered according to the severity specified by the relevant specification.

4.28.3.5 *Severities*

The severity of the test is given by nominal pulse voltage, pulse duration, pulse repetition period, total test duration and the ambient temperature.

A test severity shall be chosen from those described in Table I and shall be given in the relevant specification. When no severity is specified, severity 3 shall be used.

These severities are intended to be used with figures of permitted change of resistance similar to those used with the endurance tests.

For all severities, rectangular pulses are preferred. To collect more test data in a shorter time it shall be permitted to use exponential pulses, provided the nominal pulse voltage $\hat{U}$ and the average power P in the pulse train remain the same as with rectangular pulses.

If pulses other than those described in Appendix C are used, the shape of the pulses applied to the terminations of the resistor shall be described in full in the detail specification.

TABLE II

List of preferred severities

Severity	1 (see Note 1)	2	3	4
Nominal voltage $\hat{U}$ (multiples of U_R) (see Note 3)	10	2.5	5	4.5 $(\sim\sqrt{20})$
Pulse duration t_p (μs) (see Note 2)	150 to 170	7 to 11.5	100	820 to 1 000
Pulse repetition period T (μs) and corresponding frequency f (Hz) (see Note 2)	16 667 to 20 000	59 to 72	2 500	16 667 to 20 000
	50 to 60	14 k to 17 k	400	50 to 60
Equivalent average power P (% of P_R)	100	100	100	100
Duration of test (hours)	100	100	100	100

Notes 1. — This severity is intended to cover high pulse overload voltage requirements. It should only be applied where required.

2. — The independent parameters of Table II are $\hat{U}$ and P. The value of t_p/T (or corresponding value $t_p f$) shall be adjusted to conform to the specified values of $\hat{U}$ and P.

The pulse duration t_p shall be adjusted so that with T at a value within its tolerance the average power P has its correct value.

3. — With an upper limit as given in the relevant specification.

4.28.3.6 *Intermediate measurements*

Intermediate measurements may be performed to shorten the test in the case of failure of the resistors under test after 4, 24 and 50 hours.

4.28.3.7 *Recovery*

Recovery shall take place under standard atmospheric conditions for testing until thermal equilibrium has been reached, with a maximum of 24 hours.

4.28.3.8 *Final inspection, measurements and requirements*

The resistors shall be visually examined. There shall be no visible damage. The marking shall be legible.

The resistance shall be measured. The change of resistance with respect to the value measured initially (Sub-clause 4.28.3.3) shall not exceed the limit for the endurance test unless otherwise specified in the detail specification.

For insulated resistors only the insulation resistance shall be measured

The value shall not be less than the limit given in the detail specification.

4.28.3.9 *Information to be given in the detail specification*

a) Method of mounting of the resistor for the test.

b) Test severity, to be selected from Sub-clause 4.28.3.5.

c) Ambient temperature, if other than 25 ± 5 °C.

d) Nominal pulse voltage (as defined in Sub-clause 4.28.2.3).

e) Permissible resistance change for the endurance test.

f) Insulation resistance.

4.29 *Component solvent resistance*

4.29.1 *Initial measurement*

The measurements prescribed in the relevant specification shall be made.

4.29.2 The components shall be subjected to Test XA of IEC Publication 68-2-45 (1980), with the following details:

a) Solvent to be used:	See Sub-clause 3.1.1 of IEC Publication 68-2-45.
b) Solvent temperature:	23 ± 5 °C, unless otherwise specified in the detail specification.
c) Conditioning:	Method 2, (without rubbing).
d) Recovery time:	48 h, unless otherwise stated in the detail specification.

4.29.3 The measurements prescribed in the relevant specification shall then be made and the specified requirements be met.

4.30 *Solvent resistance of marking*

4.30.1 The components shall be subjected to Test XA of IEC Publication 68-2-45 (1980), with the following details:

a) Solvent to be used:	See Sub-clause 3.1.1 of IEC Publication 68-2-45.
b) Solvent temperature	23 ± 5 °C.
c) Conditioning:	Method 1 (with rubbing).
d) Rubbing material:	Cotton wool.
e) Recovery time:	Not applicable, unless otherwise stated in the detail specification.

4.30.2 After the test the marking shall be legible.

APPENDIX A

INTERPRETATION OF SAMPLING PLANS AND PROCEDURES AS DESCRIBED IN IEC PUBLICATION 410 FOR USE WITHIN THE IEC QUALITY ASSESSMENT SYSTEM FOR ELECTRONIC COMPONENTS

When using IEC Publication 410 (1973) for inspection by attributes the following interpretations of the clauses and sub-clauses indicated below apply for the purposes of this standard:

1.1 The responsible authority is the National Authorized Institution implementing the Basic Rules and Rules of Procedure.

1.5 The unit of product is the electronic component defined in a detail specification.

2. Only the following definitions from this clause are required:

— a defect is any non-conformance of the unit of product to specified requirements;

— a defective is a unit of product which contains one or more defects.

3.1 The extent of non-conformance of product shall be expressed in terms of percent defective.

3.3 Not applicable.

4.5 The responsible authority is the IEC Technical Committee drafting the blank detail specification which forms part of the generic or sectional specification.

5.4 The responsible authority is the Chief Inspector, acting in accordance with the procedures prescribed in the document describing the inspection department of the approved manufacturer and approved by the National Supervising Inspectorate.

6.2 The responsible authority is the Chief Inspector.

6.3 Not applicable.

6.4 The responsible authority is the Chief Inspector.

8.1 Normal inspection shall always be used at the start of inspection.

8.3.3*d)* The responsible authority is the Chief Inspector.

8.4 The responsible authority is the National Supervising Inspectorate.

9.2 The responsible authority is the IEC Technical Committee drafting the blank detail specification which forms part of the generic or sectional specification.

9.4 (Fourth sentence only.) Not applicable.
(Fifth sentence only.) The responsible authority is the Chief Inspector.

10.2 Not applicable.

APPENDIX B

RULES FOR THE PREPARATION OF DETAIL SPECIFICATIONS FOR CAPACITORS AND RESISTORS FOR ELECTRONIC EQUIPMENT

B1. The drafting of a complete detail specification by IEC Technical Committee No. 40: Capacitors and Resistors for Electronic Equipment, if required, shall begin only when all the following conditions have been met:

a) the generic specification has been approved;

b) the sectional specification, when appropriate, has been circulated for approval under the Six Months' Rule;

c) the associated blank detail specification has been circulated for approval under the Six Months' Rule;

d) there is evidence that at least three National Committees have formally approved as their own national standard, specifications covering a component of closely similar performance.

Where a National Committee formally asserts that substantial or significant use is made within its country of a part described by some other national standard, this assertion may count towards the foregoing requirement.

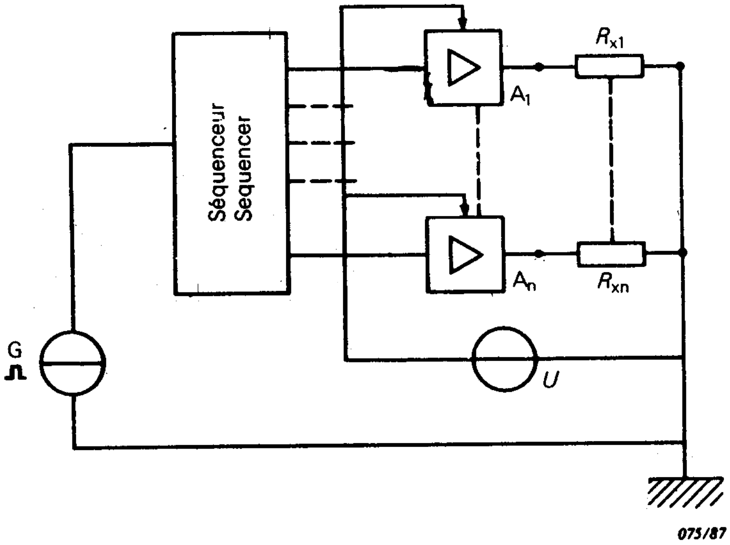
B2. Detail specifications prepared under the responsibility of Technical Committee No. 40, shall use the standard or preferred values, ratings and characteristics and severities for environmental tests, etc., which are given in the appropriate generic or sectional specifications.

An exception to this rule may only be granted for a specific detail specification, when agreed by Technical Committee No. 40.

B3. The detail specification should not be circulated under the Six Months' Rule until the sectional and blank detail specifications have been approved for publication.

APPENDIX C

EXAMPLE OF A TEST EQUIPMENT FOR THE PERIODIC PULSE HIGH VOLTAGE OVERLOAD TEST



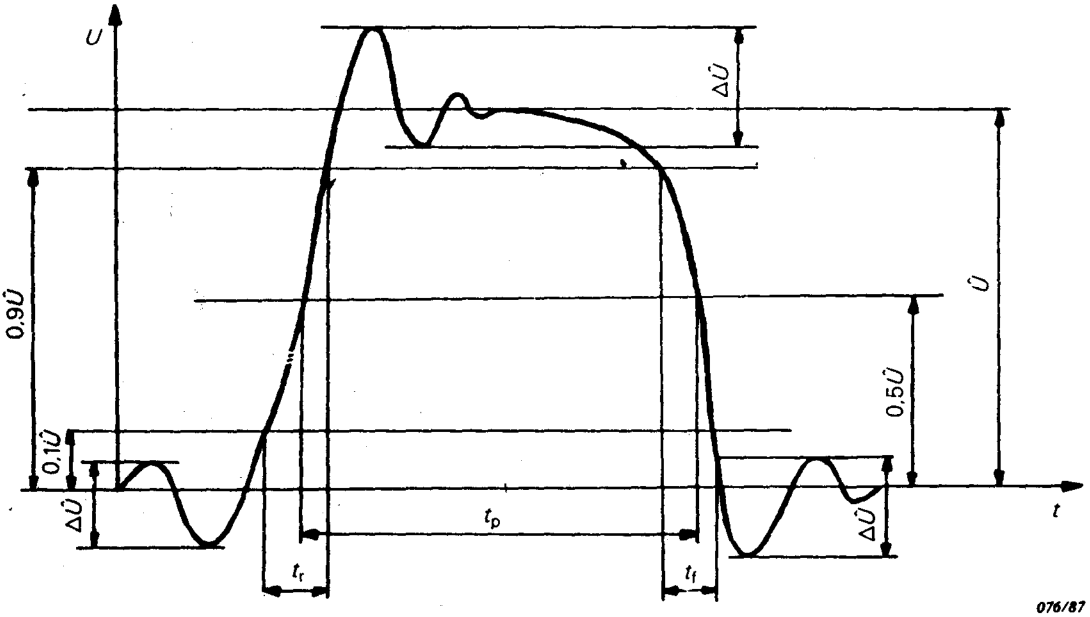
G: Pulse generator

A_1 to A_n: Power amplifiers

R_{x1} to R_{xn}: Resistors under test

U: Voltage source (Power supply)

FIG. C1. — Block diagram of a test equipment.



t_r, $t_f \leqslant 2\,\mu s$ or 10% of t_p (the highest value)

$\Delta\hat{U} \leqslant 0{,}1\,\hat{U}$

FIG. C2. — Tolerances on the pulse shape.